

WHAT IS CLAIMED IS:

- 2 1. A heat exchange catheter comprising:
3 a longitudinal catheter shaft with a proximal end and a distal end;
4 a heat exchange region comprising a plurality of heat exchange elements, each of
5 said heat exchange elements having a length and opposed ends and each of said heat
6 exchange elements being disposed such that, when the heat exchange region of the
7 catheter is positioned in a body lumen or body cavity that contains body fluid, the body fluid
8 may circumferentially surround at least a portion of each heat exchange element.
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- 2 2. The catheter of claim 1, wherein at least some of the heat exchange elements have
3 a fluid flow path therethrough.
- 4
- 5 3. The catheter of claim 2, wherein at least some of the heat exchange elements have
6 a non-circular cross-section.
- 7
- 8 4. The catheter of claim 2, wherein the shaft has a fluid inflow lumen and a fluid outflow
9 lumen and a circulation pathway therebetween for the circulation of heat exchange
10 medium, at least some of the heat exchange elements being in the circulation pathway to
11 enable circulation of a fluid heat exchange medium through the heat exchange elements.
- 12
- 13 5. The catheter of claim 4, wherein each heat exchange element has an inflow orifice
14 on one end and an outflow orifice on the opposed end, the inflow orifice and the outflow
15 orifice being in communication with the circulation pathway.
- 16
- 17 6. The catheter of claim 5, wherein each heat exchange element extends in a non-
18 linear path from its inflow orifice to its outflow orifice, the non-linear path having a least one
19 point of inflection.
- 20
- 21 7. The catheter of claim 5, wherein the catheter includes an inlet manifold open to the
22 inflow lumen and to the inflow orifice of each heat exchange element, and the catheter

1 includes an outlet manifold open to the outflow lumen and to the outflow orifice of each
2 heat exchange element.

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4 8. The catheter of claim 7, wherein the inlet manifold is disposed distally with respect
5 to the outlet manifold.

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7 9. The catheter of claim 7, wherein the heat exchange elements comprise elongate
8 hollow filaments having opposed open ends defining the respective inflow and outflow
9 orifices, and wherein each filament open end communicates with an interior space in a
10 respective manifold.

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12 10. The catheter of claim 7 wherein the heat exchange elements are longer than the
13 distance between the inlet and outlet manifold.

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15 11. The catheter of claim 1, wherein the shaft has a length and the heat exchange
16 region extends a distance that is less than one half the length of the shaft.

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18 12. The catheter of claim 11, wherein the heat exchange region is located on the distal
19 region of the shaft.

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21 13. The catheter of claim 11, further including an insulating region on the shaft located
22 proximally with respect to the heat exchange region.

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24 14. The catheter of claim 13, wherein the insulating region extends the entire length of
25 the shaft proximal of the heat exchange region.

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27 15. The catheter of claim 13, wherein the insulating region extends approximately 85-
28 90% of the length of the shaft, and a heat exchange region extends substantially along the
29 rest of the shaft.

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1 16. The catheter of claim 1, further including an insulating region on the shaft located
2 proximally with respect to the heat exchange region, and wherein the insulating region
3 comprises an inflatable balloon surrounding the shaft.
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5 17. The catheter of claim 16, wherein the shaft is within the balloon and the insulating
6 region comprises a plurality of stand-offs interposed between and spacing apart the inner
7 wall of the balloon and the shaft.
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9 18. The catheter of claim 16, wherein the insulating region comprises a plurality of the
10 balloons surrounding the shaft and a sleeve encompassing the balloons.
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12 19. The catheter of claim 1, wherein there are at least three heat exchange elements.
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14 20. The catheter of claim 19, wherein the heat exchange elements are evenly
15 circumferentially distributed about the shaft.
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17 21. The catheter of claim 1, wherein the heat exchange elements are flexible and each
18 is constrained along a portion of its length with respect to the shaft so that a free end of
19 each heat exchange element is permitted to drift freely within the body fluid.
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21 22. The catheter of claim 21, wherein the heat exchange elements comprise very thin-
22 walled balloons.
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24 23. The catheter of claim 21, wherein the heat exchange elements have walls permitting
25 a high rate of conductive heat transfer therethrough.
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27 24. The catheter of claim 21, wherein the heat exchange elements are hollow, the shaft
28 including a fluid circulation path, and the hollow interior of the heat exchange elements
29 being in fluid communication with the fluid circulation path.
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1 25. The catheter of claim 24, wherein each heat exchange element has a distal end and
2 a proximal end, the distal end of each being attached to the catheter shaft.

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4 26. The catheter of claim 24, wherein each heat exchange element has a distal end and
5 a proximal end and extends from a proximal end of the catheter shaft to beyond the distal
6 end of the catheter shaft, the plurality of heat exchange elements being retained closely
7 together by the shaft except at their distal ends where they are separate and permitted to
8 float freely in the body fluid.

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10 27. The catheter of claim 26, further including a proximal manifold for supplying and
11 removing a heat exchange medium to the hollow interior of each heat exchange element.

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13 28. The catheter of claim 27, wherein each heat exchange element is formed with a
14 coaxial flow path, the heat exchange medium being supplied to an inner lumen and
15 removed from an outer lumen.

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17 29. The catheter of claim 27, wherein each heat exchange element comprises a loop
18 of a single lumen tube, the heat exchange medium being supplied to the tube lumen.

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20 30. The catheter of claim 1, wherein each heat exchange element comprises a filament
21 having a distal end and a proximal end, the distal end being attached to the catheter shaft,
22 and further including a spring member positioned between the filament and the shaft and
23 adapted to compress upon application of an external force to the catheter as it is being
24 inserted into the body cavity, and expand in the absence of such an external force to
25 maintain the filament a predetermined radial distance away from shaft.

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27 31. The catheter of claim 30, wherein each filament is further attached at its proximal
28 end to the catheter shaft, each filament being hollow and providing a fluid flow path
29 therethrough for passage of a liquid heat exchange medium.

1 32. The catheter of claim 1, wherein each heat exchange element comprises a rod-like
2 filament having a flow disrupting rib disposed thereon.
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4 33. The catheter of claim 32, wherein the flow disrupting rib is helically disposed about
5 the filament.
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7 34. The catheter of claim 32, wherein the flow disrupting rib is circumferentially disposed
8 about the filament.
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10 35. The catheter of claim 1 wherein said catheter shaft comprises a plurality of heat
11 exchange elements substantially surrounded by a sleeve and wherein the heat exchange
12 region comprises portions of the heat exchange elements that protrude out of said sleeve.
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14 36. A system for heat exchange with a body fluid, comprising:
15 a liquid heat exchange medium,
16 a heat exchange catheter having a shaft with a proximal end and a distal end, the
17 distal end of the catheter shaft being percutaneously insertable into a body cavity, the shaft
18 having a circulation pathway therein for the circulation of heat exchange medium
19 therethrough, and
20 a plurality of heat exchange elements each having a length and opposed ends, each
21 element being attached on at least one of its ends to the shaft and disposed so that when
22 inserted in a fluid body cavity having body fluid therein, the body fluid may circumferentially
23 surround each heat exchange element along a portion of the length of the heat exchange
24 element.
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26 37. A method of exchanging heat with a body fluid of a mammal, comprising:
27 providing a catheter having a circulatory fluid flow path therein and a heat exchange
28 region including a plurality of heat exchange elements each having a length and opposed
29 ends, each element being attached on at least one of its ends to the heat exchange region
30 and disposed so that when inserted in a fluid body cavity having body fluid therein, the

1 body fluid may circumferentially surround each heat exchange element along a portion of
2 the length of the heat exchange element,

3 inserting the catheter into a body cavity and into contact with the body fluid,

4 flowing a liquid heat exchange medium through the circulatory flow path so that the
5 medium exchanges heat with the body fluid through the heat exchange elements.

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7 38. The method of claim 37, wherein the heat exchange elements are hollow and the
8 circulatory fluid flow path extends through the heat exchange elements, the method
9 including flowing fluid through the heat exchange elements.

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